From Revised Bof
Ambient Water Quality
Criteria for Copper
~~Aquatic Toxicology~~
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contain too few experimental details to allow interpretation of the results or the exposure were too short and/or concentrations too high for meaningful results to have been attained. Shcherban (1977) did not report useable results, and Brkovic-Popovic and Popovic (1977a,b) used questionable dilution waters. High control mortalities occurred in all except one test reported by Sauter, et al. (1976). Many papers, such as those by Karbe (1972), Saward, et al. (1975), Solbe and Cooper (1976), Majori and Petronio (1973), Hestinga (1976), Mishra and Srinastara (1980), and Pant, et al. (1980), could not be used because they only contain data on non-resident species.

The reports by Black (1974), Tarzwell and Henderson (1960), Tsai and McKee (1978), and Anderson and Spear (1980a, 1980b), and the review of Spear and Pierce (1979b) only contain data published elsewhere.

Summary

Acute toxicity data are available for species in 26 families of freshwater animals. At a hardness of 50 mg/l the families range in sensitivity from 12.19 µg/l for daphnids to 10,160 µg/l for stoneflies. Statistically significant regressions of acute toxicity on water hardness are available for eight species, with toxicity decreasing as hardness increases. Additional data for several species indicate that toxicity also decreases with increases in alkalinity and total organic carbon.

The range of acute values indicates that some of the more resistant species could survive in copper concentrations over 800 times that which would be readily lethal to the more sensitive species. Among the more sensitive species are daphnids, scuds, midges, and snails which form the major food-webs for both warm- and cold-water fishes. Concentrations of

copper lethal to those sensitive organisms in soft water are only slightly above those chronically toxic to most fish and invertebrate species.

Chronic values are available for eleven freshwater species, ranging from a low of 3.873 µg/l for brook trout to 60.36 µg/l for northern pike. Fish and invertebrate species seem to be about equally sensitive to the chronic toxicity of copper. The two most sensitive species, bluntnose minnow and G. pseudolimnea, are both important food organisms.

Copper toxicity has been tested on a wide range of plant species, with results approximating those for animals. Complexing effects of the test media and a lack of good analytical data make interpretation and application of these results difficult. Protection of animal species, however, appears to offer adequate protection of plants as well. Copper does not appear to bioconcentrate very much in the edible portion of freshwater aquatic species.

The acute toxicity of copper to saltwater animals ranges from 5.8 µg/l for the blue mussel to 600 µg/l for the green crab. A chronic life-cycle test has been conducted with a mysid, and adverse effects were observed at 77 µg/l but not at 38 µg/l, which resulted in an acute-chronic ratio of 3.346. Several saltwater algal species have been tested, and effects were observed between 5 and 100 µg/l. Oysters can bioaccumulate copper up to 28,200 times, and become bluish-green, apparently without significant mortality. In long-term exposures, the bay scallop was killed at 5 µg/l.

National Criteria

To protect freshwater aquatic life and its uses, in each 30 consecutive days: (a) the average concentration (in µg/l) of active copper (operationally defined as the copper that passes through a 0.45 µm membrane

filter after the sample is acidified to pH = 4 with nitric acid) should not exceed the numerical value given by $e^{(0.905[\ln(\text{hardness})]-1.785)}$; (b) the maximum concentration (in µg/l) should not exceed the numerical value given by $e^{(0.905[\ln(\text{hardness})]-1.413)}$; and (c) the concentration (in µg/l) may be between $e^{(0.905[\ln(\text{hardness})]-1.785)}$ and $e^{(0.905[\text{hardness})]-1.413)}$ for up to 96 hours. For example, at hardnesses of 50, 100, and 200 mg/l as $CaCO_3$ the criterion average concentrations of active copper are 5.8, 11, and 20 µg/l and the criterion maximum concentrations are 8.4, 16, and 29 µg/l.

To protect saltwater aquatic life and its uses, in each 30 consecutive days: (a) the average concentration of active copper should not exceed 2.0 µg/l; (b) the maximum concentration should not exceed 3.2 µg/l; and (c) the concentration may be between 2.0 and 3.2 µg/l for up to 96 hours.